THE HISTORY OF THE SALTON SEA.

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The Salton Sea is an accumulation of waste water in the bottom of a depression below sea level. Relatively to a real sea, it is a mere puddle or "duck pond" in a vast extent of arid desert, which at one time was the floor for a large body of brackish water. It is not a new thing, but a revival in historic times of what has probably occurred frequently in geologic history.

Salton Sea is in Imperial County, California. This county is adjacent to the Mexican border and lies immediately west of the Colorado River. A great part of the county is below sea level and the Salton Sea consists of the waste or seepage water which has found its way to the lowest point in the broad extent of depressed desert lands. In former geologic times, the head of the Gulf of California extended 200 miles farther north than it does at present, so that its waves lapped the base of the Santa Rosa Mountains and San Jacinto Peak, physical features that are now far inland. At this time the mouth of the Colorado River was in the vicinity of Yuma, Arizona, 60 miles in an air line north of where it is now. Presumably then as now, the river discharged annually into the gulf sufficient silt to cover one square mile to the depth of 53 feet. This material represented the erosion of the great canyons and plateaus of Arizona.

This extremely muddy river entered the Gulf at about 140 miles below its head. It carried the washings from the mountains and plateaus of the north, deposited its load of sediment on reaching salt water, and spread this out into a broad alluvial fan, ultimately filling that portion of the Gulf, cutting off the head and leaving it as a detached body of water. The remaining gulf had about the same dimensions and outlines that it has today. Delta growth, however, did not cease with this separation; silt continued to be brought down by the Colorado and to be deposited in its bed, along its banks, and in the still waters at its mouth. By this process a stream builds up its immediate channel, until this channel is higher than the adjacent land on either side. It is then in an unstable condition and will shift to more favorable courses at times when extreme floors breach its immediate banks. By this process continually repeated, it comes eventually to flow over all parts of its delta,

building up each part in turn, until the whole stands well above sea level. By such a process the Colorado River has built up the famous delta lands of the Imperial Valley, and meanwhile has discharged alternately into the Salton Sink and into the Gulf of California.

During those periods when it discharged into the sink, this basin was filled to the depths of about 300 feet in the deepest part and became an inland sea. During the other periods when it discharged southward away from the lake, the supply of water which it contained quickly dried away and left the old lake bottom as the Colorado Desert. Doubtless this process was repeated many times, but there exists clear evidence of only the last occupancy. This evidence is in the form of a remarkably well-preserved old water-line that rims the desert from Indio to Cerro Prieto at a height of 40 feet above sea-level. On the rocky points that projected into the lake, this shore line is indicated by thick deposits of calcium, carbonate, usually spoken of as coral by the desert dwellers because of a fancied resemblance to this mineral. Where alluvial cones and the sandy floor of the desert formed the shore line, beaches have been developed, and although of soft sand and easily eroded, they are even now well preserved, thus testifying to the recency of the action that produced them. Over the floor of the desert and along the sandy beaches are myriads of shells of brackish water mollisks that lived in this lake. So abundant are these tiny fossils in the northern end of the desert that it has been called on account of their numbers, Conchilla (Little Shell) Valley.

The botanist, too, finds curious confirmation to our story. All about the Salton Sink as far as Indio and the Palm Springs farther west are curious isolated groves of palms of peculiar sort, the *Washingtonia,* in fact now commonly planted in Southern California cities. But *Washingtonia* should stand by the sea as the palms of Florida do, run down the shores of California Gulf, and so these isolated groves are but the remnant of a tropic flora, once rich no doubt, that all but perished with the last drying of the old Salton Sea.

It is not possible to state the exact period at which this lake disappeared. The time units of geology are too large and too indefinite to translate satisfactorily into years, so that when we say the last existence of the lake and its disappearance are the most recent of geologic events, we still leave the mind groping for a definite human standard of time. It is the crudest of estimates, merely a guess, indeed, to state that, reasoning from geologic evidence alone, it may be a thousand years since the lake vanished, yet it puts into a concrete form such a guess as the geologist is able to make. When human records are studied, some evidence on this point is found, but is almost as uncertain as to time as that furnished by physical features. The Indians now living at Toro and Alamo

Bonita have distinct legends to the effect that in some time past the valley was occupied by a large body of water. They record that this water contained many fish and that it disappeared gradually, until eventually the lake became dry. When questioned as to the date of this event, they state that it occurred as long ago as the lives of four or five very old men, say three or four centuries ago at the most. It is not at all probable that their statements are accurate as to time, but by combining them with evidence furnished by physical conditions, it is possible to say that the lake may have disappeared and left the desert as we have known it in historic time, 600 or 800 years ago.

The territory now occupied by the Salton Sea was covered with immense deposits of salt which created an important industry in the Salton Sink. The salt was secured from the surface by plowing and then carried away by the carload.

The desert land south of the Salton Sea has been known for years and has had a reputation for extreme aridity. Certain adventurous men, more farsighted than others, saw the possibilities of agricultural development, finally formed a company, and succeeded in perfecting plans for diverting some of the water of the Colorado River. This was done by a cut in the west bank of the river in the United States near the international boundary.

The very boldness of the undertaking, and the novelty of the situation, added to the popular interest, which was stimulated by advertising, thousands of settlers came in and took up claims under the Homestead or Desert Act. The water was applied to the fields and thousands of acres were put under cultivation.

The rapid development of the country and increasing demand for water, and the difficulties of keeping open the original heading due to the accumulation of sediment, finally forced the owners of the canal to look about for some quicker way of getting the needed supply of water to the agricultural lands.

About the time of the greatest need of water was felt in the valley, the California Development Co., which furnished the water, appears to have reached its limit as regards funds, and with the pressure of the farmers for more water, it became necessary to make a hazardous move. It was finally determined, much against the advice of the engineers, to cut into the bank of the river and lead the water down a short quick descent to one of the old delta channels, known as the Alamo Channel. This channel is just over the Mexican border.

Accordingly, in October, 1904, what is known as heading No. 3, this being 40 to 50 feet wide and 6 to 8 feet deep, was cut in the mud bank of the river, and a small amount of water was allowed to flow down, relieving the needs of the farmers. The California

Development Co. did not have approved plans or funds available to build head works in this opening, and it was assumed that with ordinary care and watching, the channel could be kept open just sufficient to allow the needed amount of water to pass out from the west gate.

With the next rise of the river, however, the fears of the engineers were realized. Following a capricious mood, the river concluded to go down the easy channel toward the Alamo and send from day to day, an ever-increasing flood, rapidly eroding the channel. This continued until in the spring of 1905, the entire river was passing by an abrupt turn to the westward, down the Alamo channel, spreading out over the low ground, and ultimately converging northward toward the Salton Sink.

It swept out across the desert, diverging and converging, forming many streams, and in many places covering the nearly level ground with a sheet of water which extended as far as the eye could reach. All of the soil of this country had been deposited by wind or by the river in its previous excursions, and hence consisted of extremely soft layers of sandy silt or fine mud. As the water progressed toward the Salton Sink, it tended to gather into narrow streams. Gaining velocity with increase of slope, these began quickly to establish for themselves definite beds by scouring out the soft material. At first slight falls or riffles were formed. Later these progressed backward, deepening as the water scoured out the channel, which had formed in the soft earth.

Sometimes the water coming from the Colorado River overflowed the fields of the farmers and the grain or alfalfa was overtopped by the muddy flood. In a few cases where small towns had been built, such as Calexico and Mexicala, the inhabitants gathered together and with strenuous exertion, working night and day, attempted by means of low dikes to hold back the flood and direct its course. In the case of Mexicala, the converging torrents formed a deep channel and began to progress in their cutting toward the town. Attempts were made by means of heavy explosives to change the direction of the back-cutting and turn it away from the settled country. All this, however, was without effect and the wide, deep channel turned abruptly toward the town, cutting a chasm into which toppled in succession houses and barns, the railroad station, and a large part of the railroad track.

The rapid influx of the entire volume of the Colorado River was quickly noticeable in the steady rise of the Salton Sea, which, swollen by the muddy torrent, gradually engulfed the works of the New Liverpool Salt Co. and, creeping up on the ranches near Mecca, threatened to submerge the main line of the Southern Pacific Railway.

In its course from New Orleans to Los Angeles, the Southern Pacific System, passing through Arizona, reaches the Colorado River at Yuma, which it crosses on a bridge leading north. It then swings westward and after climbing a low ridge, descends into the depression occupied in part by the Salton Sea. When it reaches a point about 250 feet below sea-level, it begins to climb out northwesterly through the passes which lead to the valleys in which are situated the prosperous towns of Southern California.

The Salton Sea had only a few feet to rise before it interfered seriously with the traffic on the Southern Pacific. The wind, driving the waters toward the railroad, imperiled the track and it became necessary to rebuild it at a higher level. This was done several times in succession and temporary track after temporary track was laid down out of immediate reach of the water in the hope that the floods would subside. Popular attention was drawn to this increase in water on the sea, and without seeking the cause, many statements were printed to the effect that the ocean had broken through a crack or fissur in the earth and was coming up through the bottom of the Salton Sea. The Southern Pacific officials, however, were all well aware of the cause of the difficulty under which they were laboring, and finally finding that the California Development Co. was unable to control the floods, they by an agreement dated June 20, 1905, virtually took possession of the company, loaning it sufficient money to begin the attempt to close the break. They also rebuilt 40 miles of track on the 200-foot contour below sea-level, and for possible future use graded another line on the 150-foot contour below sea-level.

In all, seven or eight distinct attempts were made to close the break in the river bank with almost as many failures. In each case success was nearly attained, but through some inadequate preparation or sudden rise of the river, the works were swept away. It seemed as though the river was taking a malicious delight in thwarting the efforts of the engineers. At first, it was assumed that the expenditure of a small amount of money would be sufficient to close the break. The throwing back of the river into its original channel was looked upon as merely an ordinary effort in engineering work. When, however, attempt after attempt failed and larger and larger expenditures were made until over $1,000,000 was involved, the Southern Pacific officials began to awake to the fact that they had a difficult problem on hand and one which required far better equipment and preparation than had before been provided. Finally the supreme effort was made, and on Nov. 6, 1906, the break was closed, and the river forced to assume its normal channel to the Gulf.

This condition continued for just a month, when on Dec. 7, 1906,

the river in a sudden rise, forced its way under the dikes, in a few hours swept away a portion of the protecting works, passed around the dock dam, and again found its way to the Salton Sea. Then came the popular despair. One million dollars had been expended and there seemed no way of putting the river back again in place without having available an equipment and a sum of money beyond the reach of the people most immediately interested. Appeals were made to the Governor of California, and by the Governor to the President of the United States. These were given prompt attention. President Roosevelt took the matter up at once, and hastened to investigate, finding that the only man who could handle the situation, who had the equipment, the money and facilities, was Mr. E. H. Harriman, the President of the Southern Pacific, who at the same time controlled the destinies of the California Development Co.

At first in the pressure of large affairs, Mr. Harriman overlooked the fact that he was virtually the controller of the destiny of the California Development Co., and through this of the fortunes of a large community. He hesitated to advance more money, and wired to the President to that effect. Mr. Roosevelt in his telegram of Dec. 20, to Mr. Harriman, stated that—

"This is a matter of such vital importance that there is not the slightest excuse for the Development Co. waiting an hour for the action of the Government. It is its duty to meet the present danger immediately, and then the government will take up with it, as it has already taken up with Mexico, the question of providing in permanent shape, against the recurrence of the danger."

Mr. Harriman's reply on the same day stated that—

"You seem to be under the impression that the California Development Co. is a Southern Pacific enterprise. This is erroneous. It has nothing to do with the work or the opening of the canal. We are not interested in the stock and in no way control it. We have loaned it some money to assist its dealing with the situation. What the Southern Pacific has done was for the protection of settlers as well as of the tracks, but we have determined to move the tracks to higher grounds anyway. However, in view of your message, I am giving authority to the Southern Pacific offices in the west to proceed at once with efforts to close the break, trusting that the Government, as soon as you can secure the necessary Congresssional action, will assist us with the burden."

The President in reply said—

"I am delighted to receive your telegram. Have at once directed the Reclamation Service to get into touch with you so that as soon as Congress assembles, I can recommend legislation which will provide against a repetition of this disaster and make provisions for an equitable distribution of the burden."

As a result of these telegrams received in rapid succession, Mr. Harriman concluded again to make an effort, and on Jan. 12, 1907, the President, in accordance with his promise, laid the whole matter before Congress. The final effort was successful, and before the time of the spring flood of 1907, the river had once more been restored to its proper channel. During the summer, a series of dikes were built, intended to prevent any possibility of a recurrence of the danger in that part of the river.

To one who is accustomed to the surroundings of the ordinary river, the problem of turning back the Colorado River into its former channel may not appear to be very difficult. But to explain the reason of the failure in rapid succession, it should be borne in mind that the river at this point flows over deposits of silt or sand, whose character is such that under a swift current, they are torn up and carried away with wonderful rapidity. Whenever the channel, in a notable degree was confined, the water at once began hurrowing and cutting so that in some cases it is claimed that wooden piles over 70 feet long were cut out of the river almost as fast as they could be driven.

It was a simple matter to bring the work of closure or diversion to a point where it seemed as though the river could be quickly turned, but the construction of the channel due to any structure resulted in increasing the speed of the water and adding to its consequent erosive power to an extent such, that in a few hours, enormous gaps were created.

Added to the unfavorable character of the bed and banks was the fact that the river seldom remained quiet for any considerable length of time. It was subject to short, violent floods, especially from its tributary, the Gila. These, occurring at the time when the work was in a critical condition, quickly rendered useless the efforts of the constructors.

The method finally adopted for turning the stream was one whose success depended on having at hand a large railroad equipment and an enormous amount of material which could be quickly transported.

The attempt was on a gigantic scale.

First, a branch railroad was built from the main line at Pilot Knob, in California, to the break in Mexico—twelve miles—together with numerous side tracks for loaded cars.

Second, an order was issued by the Southern Pacific Railroad to every stone quarry within 350 miles. Thousands of men instantly attacked granite mountains with dynamite and steel.

Third, freight carrying business was stopped on two grand divisions of the road and every car was impressed as a rock carrier.

Fourth, a vast quantity of material was massed at the break in thousands of cars, rock, gravel, sand, clay, piles, ties, steel rails and

a host of other things. The plan was to prepare for one gigantic attack with all materials at hand. A steamer, a flat-boat, a giant dredger, steam shovels, a pile driver, steam pumps, cables, spikes, picks and hammers galore were accumulated. Then came 600 Europeans and Mexicans and 450 Indians—the largest number of the latter ever at work in one body. Then came 600 horses and mules. with a great number of plows, scrapers, carts, wagons, spades and shovels. Then up went electric lights for night work and telephones to Yuma and Los Angeles for emergency purposes. Every man from the highest engineer to the lowest Indian knew that a terrific battle was about to open. Every man of the 1,050 had been trained in engineering work before, and each knew what and when to do. If they had not been trained for critical and highly dangerous work, the Imperial Valley would still be traversed by the Colorado River and the Southern Pacific would have again been submerged. The entire southwest had been scoured for cars, and there they stood, filled with rocks, on the 10th day of August, 1906, with eight colossal locomotives to haul the immense loads.

On that day word was given and the pile driver began driving a straight row of piles across the river. Steel cables 5/8 of an inch in diameter were cut at proper lengths and attached to the piles, descending down stream. While the piles and cables were being placed, hundreds of men were at work on a flat-boat or barge, also attached to the cables fastened to the piles up stream. This boat was at the exact point where the dam was to begin. The men bound tall slender willows into bundles by means of heavy wire. These were 100 feet long and 20 inches in diameter. Twelve "dead men"—huge logs—were buried deep in the silt bank. One end of the cable was attached to each log, and the entire cable was wound on a great spool on the boat. There were twelve spools, twelve cables, eight feet apart. The willow bundles were then fastened by double loops to the cables. Thus the cables were the warp and the willows the woof of a carpet 100 feet wide and 3000 feet long. When everything was ready, a steamer pulled the boat out from the shore, the carpet slipped over the edge of the barge into the river and sank to the bottom, when silt at once began to fill in between the leaves and twigs.

Then came the carpet-tack men on a huge pile-driver; they tacked down the strip of "carpet" with heavy piles from 40 to 60 feet in length in two parallel rows. In the deepest part of the river, three widths of carpet were placed, one above the other. Now here is the secret of success. Silt brought many difficult problems. The bottom is of fine silt of great but unknown depth, anywhere from perhaps 2000 to 5000 feet. It is a remarkable substance, for a rock dropped into it under rapidly running water would have been under-

mined and settled lower and lower. Perhaps a dam could have been put in by the use of a number of millions of tons of rocks; but it was put across with only 70,000 tons—thanks to the willows. Then came the railroad builders and laid a heavy railroad on the tops of the piles from shore to shore. This roadbed is of enormous strength, necessary to hold the trainloads of rocks, and braced in every part to withstand pressure of water.

This dam was called the "Hind Dam," in honor of the field engineer, Thos. J. Hind. It was a conglomerated mass, 170 feet wide at the base, 30 feet across at the top and 35 feet high at the deepest places in the break. It was 3000 feet in length, of which 600 feet was of rock construction and 2400 feet of earth and gravel.

The work began on August 10th, 1906, and was completed on Nov. 4, 1906, at a cost of $1,500,000. But the homes of 12,000 settlers and 1,500,000 acres of rich land were saved from inundation.

For a period of 35 days the river flowed on, when on December 7th, a break occurred about 2500 feet below the works, and was 1100 feet wide.

The engineer corps were again reassembled, E. K. Clark, engineer of the Tucson division of the Southern Pacific, placed in direct charge, and work was recommended to solve this troublesome problem.

To build the "Clark Dam," no attempt was made to follow science. The Southern Pacific placed their entire road subject to the orders of the engineers, and material of almost every kind were rushed to the break from points far and near as fast as it could be taken care of. Piles were driven, a temporary road was constructed across the break, and there was almost a continuous dumping of rocks, gravel and dirt into the gap. A carload of material was dumped every seven minutes, both day and night, and in the short period of thirteen days, 100,000 tons were disposed of, bringing the dam up to the water level. Much of the material was hauled a distance of 380 miles. The "Clark Dam" was practically completed February 10, 1907, and the river was declared conquered. The dam proper is 1200 feet in length, of which 700 feet is of rock and 500 feet of gravel and earth. The California Development Co. and the Southern Pacific expended on these two dams and other nearby levees, a sum in excess of $3,500,000.

The Colorado River was thus directed onward and no further breaks have occurred. Steel and concreate head-gates have been built at the entrance to the irrigation canals and no further trouble is anticipated.

At its greatest extent the Salton Sea covered about 400 square miles, at a maximum depth of about 72 feet. The bottom of the Sink in November, 1904, just after the cut was made, stood 273.5 feet

below mean sea-level. The rise during November and December of that year was 0.8 feet. During 1905, it was 21.9 feet. In 1906, the water continued to rise and increased in depth by 49.8 feet; but in 1907, the closing of the break in February was followed by a decline beginning in March, the net fall, however, being only 0.18 feet. The level on January 1, 1908 was 201.18 feet below mean tide. The decline has continued ever since. At present, the Salton Sea is about 350 square miles in extent with a maximum depth of about 60 feet. The evaporation, however, is offset to a great degree by the surplus water not used in irrigation from the canals. This water flows down the incline till it finds the Salton Sea. However, six to eight square miles of land is reclaimed each year from the Salton Sea, and this will continue until the area of the lake is so small that the overflow from the canals will equal the evaporation.